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INFLUENCE OF SOME BIO-CHEMICAL PHOSPHORUS FERTILIZATION REGIMES ON YIELD AND SEED QUALITY OF SOME LENTIL VARIETIES

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ABSTRACT

This investigation was carried out in the Experimental Farm, Fac. of Agric., Zagazig Univ. Ghazala farm, Sharkia Governorate Egypt, during 2017/2018 and 2018/2019 seasons. The study was designed to investigate the effect of four phosphorus bio-chemical fertilization regimes (F_1:100% chemical phosphorus”15.5 kg P_2O_5”, F_2:50% of F_1+phosphorein, F_3:25% of F_1+ phosphorein and F_4: sole phosphorein) on the yield and seed quality of three lentil varieties (Giza9, Sina1 and Giza29). Results indicated that, with exception for 1000 seed weight, lentil variety Giza-9 significantly surpassed Sina1 and Giza29 in plant height, No. of branches/plant, No. of pods/plant, seed yield/fad., and biological yield/fad., as well as harvest index. On the other hand, Sina1 recorded the highest 1000 seed weight. Although Giza29 recoded the lowest values in yield and its components, it has the highest seed protein (%) and seedling root length. The maximum plant height (cm), No. of branches/plant, No. of pods/plant and No. of seeds/pod was obtained with suppling 100% chemical phosphorus. Supremacy each of seed index, lentil seed yield /fad, biological yield /fad and harvest index was the result from suppling either % 15.5 kg P_2 O_5/fad. 100% P or 50 %P+ phosphorein, both fertilization regimes 25% P + phosphorein and sole biofertilizer phosphorein ranked third and fourth. The same trend was noted in protein yield/fad, root length, shoot length as well as seedling vigor index.

INTRODUCTION

Lentil (*Lens culinaries*, subsp. Culinaris Medikus) occupies the top position in food legume crops grown in Egypt. It is grown since 8000 years ago **(Cokkizgin and Shtaya, 2013; Mitiku, 2016).** It is rich in nutritional value, seeds contain 28.6-31% protein, 60-65% carbohydrate, 3.1% ash, 0.45% phosphorus, 1.16% potassium, 10.0% magnesium and 0.07% calcium and vitamins (A, B and B6). Moreover, it has ability to fix atmospheric nitrogen with Rhizobia so it reduces the dependence on mineral nitrogen fertilization and plants can be grow in rotation with cereal crops in order to reduce demand for nitrogenous fertilizers. Besides, lentil straw contains almost 4.4, 10.2, 50, 1.8, 12.2 and 21.4% protein, moisture, carbohydrate, fat, ash and fiber, respectively, which increase using it as forage for animal **(Roy *et al*., 2010; Abbeddou *et al*., 2011).**

In Egypt, lentil area is about 2000 fad with productivity of 1.45 ton/fad., and average production of 34,434 to 892 ton/ year, respectively **(FAOSTAT, 2020).**

Crops need adding recommended fertilization for yield, seed quality and soil. The continuous use of chemical fertilizers causes negatively effect on human, animal, plant and environment. It's important overcome this problem by exploring

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alternative source, which is low, effective and safe to the environment. Biofertilizers, are alternate source of chemical fertilizer **(Baset and Shamsuddin, 2010).** Biofertilizers are important, ecofriendly, non-hazardous and non-toxic **(Sharma *et al*., 2007).** A lot number of bacterial species, mostly associated with the plant roots, may exert a beneficial substance to plant growth. Biofertilizers includes the nitrogen fixing, phosphate solubilizing micro-organisms. Phosphate solubilizing bacteria partly solubilizes inorganic and insoluble phosphate and improves applied phosphorus use efficiency, stimulating plant growth by providing hormone, vitamin and other growth promoting substances **(Gyaneshwar *et al*., 2002).**

Phosphorus is the second major plant nutrient which is essential for living cell normal plants. Phosphorus fertilization is more important for legumes than nitrogen, it controls all bio-living processes including energy transport system **(Donahue *et al*., 1990)** energy storage and transfer, photosynthesis, nutrient movement within the plant and transfer of genetic characteristics from one generation to the next. Phosphorus is a constituent of ATP, phospholipid, ADP and several coenzymes. It plays an important role in the establishment of legume seedling, roots and shoots **(Fathy, 2014).**

Most soils contain larger amount of fixed form of P than available P, a large part of which has accumulated as a fertilizer of regular applications of P fertilizers. But a large percentage of soluble chemical phosphate added to soil is fixed as insoluble forms soon after application and becomes unavailable to the plants. In acid soils, free oxides and hydroxides of Al and Fe fix P, while in alkaline soils it is fixed by Ca **(Vassileva *et al*., 2001; Khiari and Parent, 2005).** So, P availability to the crops is very low. Microorganisms such as phosphate solubilizing bacteria (*Psudomonas* sp., *Bacillus* sp., *Micrcoccus* sp. *etc*.) are known to convert insoluble inorganic phosphorus into soluble form that could be utilized by the plants **(Fankem *et al*., 2006; Vikram, 2007).** Some of phosphate-solubilizing bacteria (PSB) are used as phosphate biofertilizers for crop production. They are finding in soil but usually in numbers not high enough to rhizosphere of plants. so, inoculation of soils or seeds by PSB at a much higher concentration is needed.

There are different lens genotypes appeared some genetic variation for plant height, number of branches, number of pods per plant, number of seeds per plant and yield **(Karadavut and Palta, 2010).** performance of different lentil varieties needs to be evaluated for productive efficiency.

This study aims to study the effect of biochemical phosphorus fertilization regimes on yield, yield attributes, seed quality as well as germination and seedling growth patterns of three lentil varieties.

MATERIALS AND METHODS

Two field experiments were conducted during 2017/2018 and 2018/2019 seasons at the Experimental Farm. Fac. Agric., Zagazig Univ., (Ghazala Village), Sharkia Governorate, Egypt. The experiments aimed to study the effect of biochemical phosphorus fertilization regimes on yield, yield attributes, seed quality as well as germination and seedling growth pattern of three lentil varieties. The experiment was designated as split-plot, the main plots were distributed in a randomized complete block design with three replicates. Before sowing, experimental soil samples were randomly collected from the topsoil layer (0-30 cm) for estimating some mechanical and chemical properties of soil according to **Jackson (1973).** Mechanical and chemical analyses of soil are listed in Table 1. Lentil

Table 1. Soil mechanical and chemical analyses of the experimental site at 30 cm soil depth (average of both seasons)

Soil property	Value
Mechanical analysis:	
Sand (%)	20.65
Silt (%)	20.95
Clay (%)	58.40
Soil texture	Clay
Chemical analysis:	
pH	7.37
Total N (%)	0.09
Available P (ppm)	8.199

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varieties Giza 9, Sina1 and Giza29 were kindly obtained from legume seeds Research Department, Agricultural Research Centre in Giza Egypt. Lentil varieties were cultivated in the main plots. The biochemical fertilization phosphorus treatments occupied the sub-plots, and were as follows:

F_1: 100% P (15.5 kg P_2O_5), F_2: 50% of F_1 dose (50 kg) + phosphorein (bio-fertilizer), F_3: 25% of F_1 dose (25 kg) + phosphorein (bio-fertilizer) and F_4: bio-fertilizer only (phosphorein) (1 package = 300 g**).** The area of each sub- plot (6 m^2) contains 10 rows, 20 cm apart and 3 meter long. The space between each plot was 1 m. Seeding rate at 50 kg fad., was inoculated with strain of *Rhizobium leguminosarum*, Vulgaris. Sowing dates were on 10^th^ and 15^th^ of November in the first and second seasons, respectively. Calcium superphosphate (15.5% P_2O_5) as chemical fertilizer was supplied at sowing, whereas the amount was determined based to each phosphorus rate in treatments F_1, F_2 and F_3. Phosphate dissolving bacteria (PDB) is an Egyptian bio- fertilizer commercially named phosphorein which was used in treatments (F_2, F_3 and F_4). Seeds were inoculated prior sowing with phosphorein. Flood irrigation was practiced, plants were irrigated only twice during each season. The preceding crops were corn and hibiscus in first and second seasons, respectively.

Recorded Data

Yield and yield attributes

At harvest (140-150 DAS), ten around plants were randomly taken from each plot to determine plant height, number of branches/plant, number of pods/plant and number of seeds/pod. Plants of one m^2 from the inner rows were harvested and used to determine 1000 seed weight, seed yield/fad., and biological yield/fad. Harvest index was calculated as follows = (economic yield/ biological yield) × 100.

Seed quality

After harvesting, seeds were stored for 6 months in jute packs in seed laboratory, Faculty of Agriculture, Zagazig University in each season to conduct standard germination test. Each treatment was divided into four replicates, each with 25 seeds, seed lot replicate was germinated in rolled paper at temperature 20˚C.

Germination and seedling characters were measured at laboratory during the seventh day. Final germination percentage was calculated using the following formula: Germination (%) = (Number of final germinated seeds)/(Total number of tested seeds) × 100, Shoot and radical lengths were randomly recorded from twenty seedlings were also measured. Seedling fresh weight and seedling dry weight. Seedling vigor index was calculated according to **Abdul-Baki and Anderson (1970)** as follows: Seedling vigor index= (shoot length + radical length) × germination percentage. Seed protein content percentage was estimated by the micro Kjeldahl method to determine total nitrogen as outlined in **AOAC (2000).** Seed protein content was calculated by multiplying total nitrogen by 5.9 and Protein yield/fad., was calculated by multiplying the crude protein percentage by seed yield/fad.

Statistical Analysis

The data obtained from each trail was analyzed according to analysis of variance of split plot design by using computer program **MSTAT-C (1989)** as described by **Snedecor and Cochran (1967).** Then, the combined analysis was calculated for all studied traits in both seasons. The differences among treatments were compared using Duncan's multiple range test **(Waller and Duncan, 1969)**, where means denoted with the different letters are statistically significant.

RESULTS AND DISCUSSION

Seed Yield and its Attributes

Varietail variation

Significant differences were noticed among the three lentil varieties for most of the studied traits. It is obvious that Giza 9 was superior above Sinai1 and Giza 29 varieties in plant height, No. of branches and pods/plant in both seasons and combined analysis. While Sinai1 recorded the lowest value for each of plant height and No. of pods/plant. Giza 29 produced the fewest No. of branches/plant (Table 2). These results may be due to the genetic variability between the three tested varieties and the response of each to the environmental conditions during the growing seasons. These results are in harmony with those obtained by **Khattab *et al.* (2016).**

In Table 3, the highest 1000 seed weight was that of lentil variety Sinai1. Giza 9 and Giza 29 lentil varieties ranked second and third. The highest, the moderate the lowest yields/fad., were yielded by lentil varieties Giza9, Sinai1 and Giza29, orderly in both seasons and their pooled data. Superiority of Giza9 variety in seed yield/fad., was the resultant of its superior in No. of pods/ plant. These results matched well with those of **Koller *et al*. (1976).**

Results in Table 4 disclose distinct supereminence for lentil variety Giza9 in both biological yield and harvest index over both Sinia1 and Giza29 varieties in the combined analysis. Superiority of lentil variety Giza9 in both economic and biological yields was in response with its outbrave in each of plant height, No. of branches and pods/plant. **Fageria (1992)** resolved that biological yield, economic yield and harvest index were related to each other, so economic yield can be increased by increasing total dry matter production or by increasing harvest index. In this study, economic yield of Giza9 lentil variety increased due to increasing both biological yield and harvest index that could be ascribed to its superiority in dry matter production and accumulation, besides its efficiency in translocation of assimilates from source to sink. Protein (%) in lentil seeds exhibited that Giza 29 variety has the highest content and ranked first, followed by Sinai1 variety, then Giza 9 ranked third. The same trend was emerged from the

Table 2. Plant height, No. of branches/plant and No. of pods/plant of three lentil varities as influenced by biochemical phosphorus fertilization regimes during 2017/ 2018 and 2018/2019 seasons and their combined

Main effect	Plant height (cm)			No. of branches /plant			No. of pods/plant		
	2017/18	2018/19	Comb.	2017/18	2018/19	comb	2017/18	2018/19	Comb.
Lentil varieties (V)									
Giza 9	40.54	41.40	40.97	2.82	3.6	3.21	35.62	39.56	37.59
Sinai 1	32.06	39.80	35.93	1.88	2.8	2.34	23.05	30.50	26.77
Giza29	38.83	38.65	38.74	2.39	2.7	2.55	34.33	27.34	30.88
F-test	*	*	*	*	NS	*	*	*	*
LSD at 5%	1.61	0.098	1.02	0.171		0.48	1.01	0.78	0.69
Biochemical fertilization regimes (F)									
F_1	39.91	45.71	42.81	2.60	4.35	3.47	31.97	41.27	36.62
F_2	34.84	41.96	38.40	2.44	3.15	2.80	28.60	34.80	31.70
F_3	38.06	37.71	37.88	2.09	2.35	2.22	30.87	28.82	29.84
F_4	35.77	34.42	35.09	2.32	2.26	2.29	32.56	25.11	28.83
F-test	*	*	*	*	*	*	*	*	*
LSD at 5%	1.6	0.73	0.94	0.193	0.305	0.16	0.89	1.24	0.601
Interaction									
V×F	*	*	*	*	*	*	*	*	*

F_1, F_2, F_3 and F_4 are 100% chemical phosphorus (15.5 kg P_2O5/fad.), 50% of F_1 + phosphorein, 25% of F_1 + phosphorein and sole phosphorein in respective order.

Table 3. Number of seeds/pod, 1000 seed weight and seed yield of three lentil varieties as influenced by biochemical phosphorus fertilization regimes during 2017/2018 and 2018/2019 seasons and their combined.

Main effect	No. of seeds/pod			1000 seed weight (g)			Seed yield (kg/fad.)		
	2017/18	2018/19	comb	2017/18	2018/19	Comb	2017/18	2018/19	Comb.
Lentil varieties (V)									
Giza 9	1.45	1.9	1.67	24.37	25.15	24.76	744.24	783.03	763.64
Sinai 1	1.33	1.68	1.5	33.52	34.19	33.86	708.84	727.15	717.99
Giza 29	1.36	1.58	1.47	23.07	24.06	23.57	652.21	686.41	669.31
F-test	NS	NS	NS	*	*	*	*	*	*
LSD at 5%				0.95	0.625	0.384	5.11	16.55	7.86
Biochemical fertilization regimes: (F)									
F_1	1.50	2.06	1.78	26.85	27.90	27.38	758.24	796.69	777.47
F_2	1.32	1.68	1.51	27.03	28.64	27.83	773.32	817.69	795.51
F_3	1.33	1.57	1.45	26.84	27.41	27.13	675.91	693.15	684.53
F_4	1.36	1.55	1.46	27.25	27.24	27.24	599.59	621.24	610.42
F-test	NS	*	*	NS	*	*	*	*	*
LSD at 5%		0.21	0.16		0.864	0.459	38.53	22.91	28.57
Interaction									
V×F	NS	*	NS	NS	*	*	*	NS	*

F_1, F_2, F_3 and F_4 are 100% chemical phosphorus (15.5 kg P_2O_5/fad.), 50% of F_1 + phosphorein, 25% of F_1 + phosphorein and sole phosphorein in respective order.

Table 4. Biological yield/fad.,Harvest index and protein yield/fad.,of three lentil varieties as influenced by biochemical phosphorus fertilization regimes during 2017/2018 and 2018/2019 seasons and their combined.

Main effect	Biological yield (ton/fad.)			Harvest index			Protein yield (kg/fad.)		
	2017/18	2018/19	Comb.	2017/18	2018/19	Comb.	2017/18	2018/19	Comb.
				Lentil varieties (V)					
Giza 9	2.13	2.23	2.18	34.87	35.10	34.98	188.88	193.07	190.97
Sinai 1	2.04	2.15	2.10	34.76	33.64	34.20	191.48	191.16	191.32
Giza 29	1.99	2.11	2.05	32.49	32.53	32.51	186.26	188.61	187.44
F-test	*	*	*	*	*	*	NS	NS	NS
LSD at 5%	0.061	0.074	0.016	1.07	1.59	0.5			
				Biochemical fertilization regimes(F)					
F_1	2.21	2.32	2.27	34.45	34.19	34.32	201.93	205.40	203.67
F_2	2.16	2.29	2.23	35.89	35.65	35.77	208.65	214.37	211.51
F_3	1.96	2.05	2.00	34.68	33.85	34.27	183.17	181.19	182.18
F_4	1.91	1.98	1.95	31.19	31.33	31.26	161.73	162.84	162.28
F-test	*	*	*	*	*	*	*	*	*
LSD at 5%	0.09	0.067	0.069	1.84	1.59	1.54	12.3	9.98	10.32
				Interaction					
V×F	*	*	*	*	NS	NS	*	*	*

F_1, F_2, F_3 and F_4 are 100% chemical phosphorus (15.5kgP_2O_5/fad.), 50% of F_1 + phosphorein, 25% of F_1+ phosphorein and sole phosphorein in respective order.

differences between cultivars in several studies such as, **Mekkei and El-Haggan (2013), Biçer *et al.* (2018) and Singh *et al.* (2018).**

Effect of biochemical phosphorus fertilization regimes

Results in Tables 2 and 3 points to the superiority of the chemical phosphorus fertilization regime (F_1) with 15.5 P_2O_5/fad. Wherein, this fertilization regime caused operative increment in each of plant height (42.81cm), No. of branches/plant (3.47), No. of pods/plant (36.62) and No. of seeds/ pod (1.78). On the contrary, sole bio-phosphorus fertilization regime with phosphorein (F_4) exiguously affected the four traits previously mentioned, the shortest plants (35.09cm), fewer branch number/ plant (2.29), fewer pod number/ plant and fewer seed number/pod (1.46) were the resultant of sole bio fertilization regime. Dualist application of chemical and bio fertilizer of phosphorus as in F_2 and F_3 fertilization regimes ranked second and third in plant height, branch number/plant and pod number/plant. Sole bio- fertilizer (F_4) *viz* sole chemical recommends fertilization rate (15.5kg P_2O_5/fad) caused dogmatic decrease in each of plant height (18.03%), branch number/plant (34.01%) and pod number/plant (21.27%) as calculated from the combined analysis. Where phosphorus is an essential element for photosynthesis, root development, directly affects the root growth **(Purushottam *et al.*, 1995)**, partly translocated to leaves and seed formation as well as nitrogen uptake **Singh (1998) and Zeidan (2007)**. From the perusal of the results in Table 3, it is evident from the combined analysis that dual application of 50% of recommended chemical phosphorus rate and bio-fertilization with phosphorein (F_2) produced the highest seed yield (795.51kg/fad.) which is significantly at par with the seed yield (777.47 kg/fad.) obtained from the sole chemical recommended phosphorus application. Pointedly it could be ascribed to the 1000- seed weight which valued 27.83 g in F_2 fertilization regime viz 27.38 g in F_1 fertilization regime. Accordingly, both treatments (F_1 and F_2) were at par in the seed yield/fad with operative increase compared with F_3 and F_4 fertilization regimes. **Fageria (1992)** concluded that in legumes, yield is determined by number of pods per unit area, seeds per pod, and weight of seeds or seed index. Seed index of lentil tended to be essential yield component, so its relative excellency (27.83 g) under dual application of 50% of recommended chemical phosphorus level and bio- fertilization with phosphorein (F_2) compared to seed index 27.38 g under application of sole chemical phosphorus (F_1) caused the relative increase in seed yield (795.51kg/fad.) under F_2 fertilization regime.

Results of both seasons and their consolidated analysis, exhibited that lentil biological yield, harvest index and protein yield (Table 4) were significantly at par under fertilization regimes F_1 and F_2. The better growth due to bio-fertilizer and phosphorus may be due to better availability of nutrients during the crop growth period. The mechanisms of growth promoting by bacteria might be due to synthesis of the plant hormones indole acetic acid **(Barozanl and Jacob, 1999)**, cytokinin **(Tummusk *et al*., 1999)**, and gibberellin **(Karakoc and Aksoz, 2006)**; also plant produced ethylene but carboxylate deaminase by bacterial and increased mineral N and P availability of the soil. The phosphate solubilizing bacteria (phosphorein) help to release unavailable soil phosphorus and may increase the efficiency of applied phosphatic fertilizers. Similar results were also reported by **Haque and Khan (2012).** Also, **Shahid and Janardan (2016)** reported that this stimulating effect of PSB in yield attributes might be due to more availability of phosphorus to the plants and more synthesis of proteins, fats and carbohydrates.

Interaction Effect

Results reported in Tables 2, 3 and 4 shows that plant height, number of branches / plant, number of pods/ plant, 1000 seed weight, seed yield/fad., biological yield/ fad., and protein yield/fad., were significantly affected by the interaction between varieties and phosphorus treatments. Results showed that the highest plant height, number of branches/plant, number of pods/plant and protein yield/ fad was obtained when lentil variety Giza 9 supplied with 100% chemical phosphorus (Figs. 1, 2, 3 and 7). The highest seed yield /fad and biological yield/fad., each was attained due to the interaction effect between Giza9 lentil variety and F_2 fertilization regime (50% F_1 recommended chemical phosphorus + phosphorein) (Figs. 5 and 6).

Allusion to the impact of the interaction effect on seed index and protein yield (kg/fad.) Figs. 4 and 7 assert the efficient impact of the interaction between Sinia1 lentil variety and the F_2 fertilization regime (50% of recommended chemical P + phosphorein).

Seed quality

Varietal variation

Results in Tables 5 and 6 show highly significant differences among the three varieties in seed protein (%) and seedling length (cm) in both seasons and their combined. Giza29 lentil variety exhibited paramountcy values above Giza9 and Sinai1 for all seed quality except protein yield/fad., germination (%), seedling fresh weight, seedling dry weight and seedling vigor index which were not affected by varietal variation. The results of seed protein (%) is presented in Table 5 corroborated that Giza29 lentil variety surpassed the other two varieties, the increment amounted 5.15

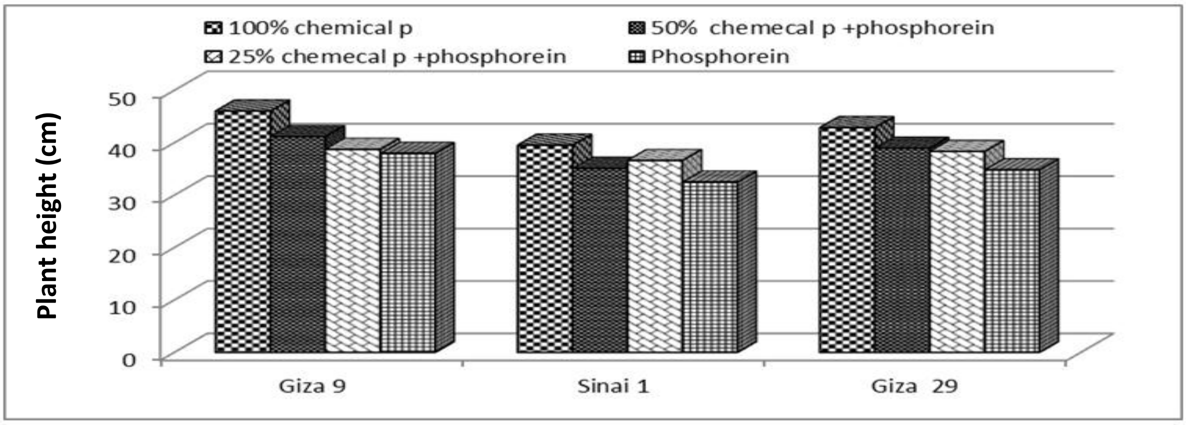

Fig. 1. Plant height (cm) as affected by the interaction between lentil varieties and phosphorus fertilization regimes

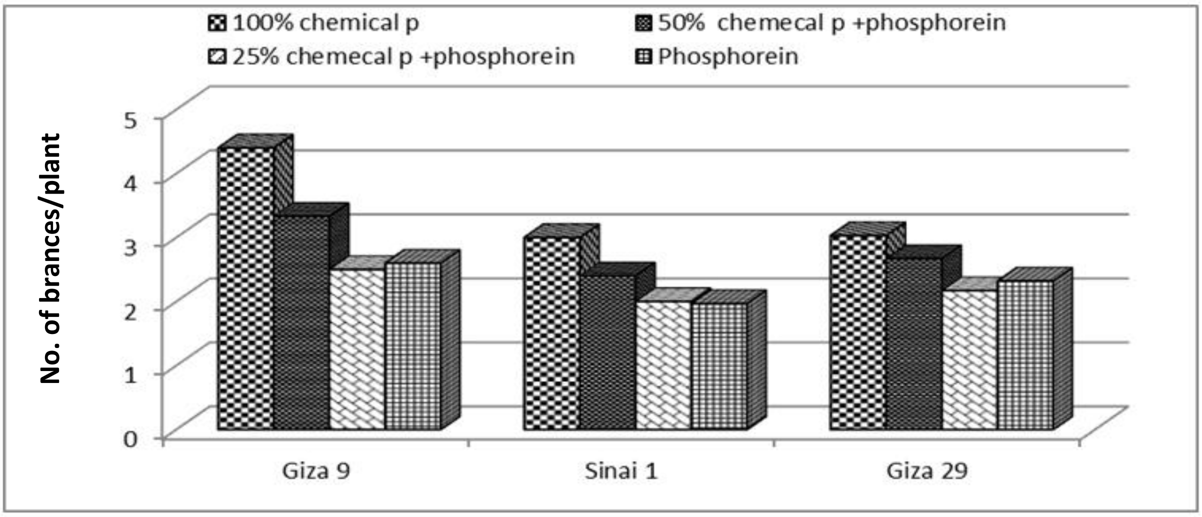

Fig. 2. No. of branches/plant as affected by the interaction between lentil varieties and phosphorus fertilization regimes

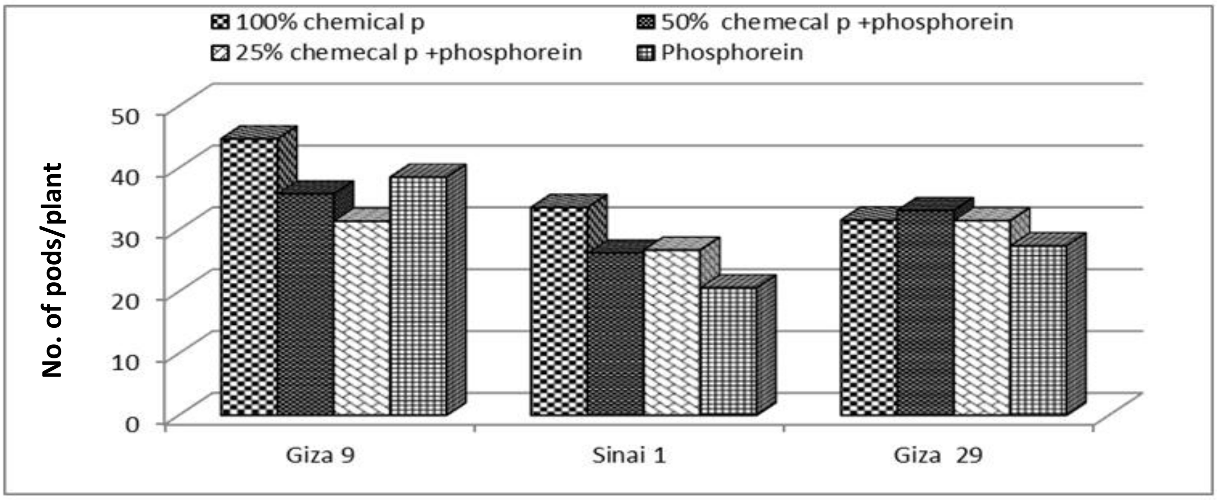

Fig. 3. No. of pods/plant as affected by the interaction between lentil varieties and phosphorus fertilization regimes

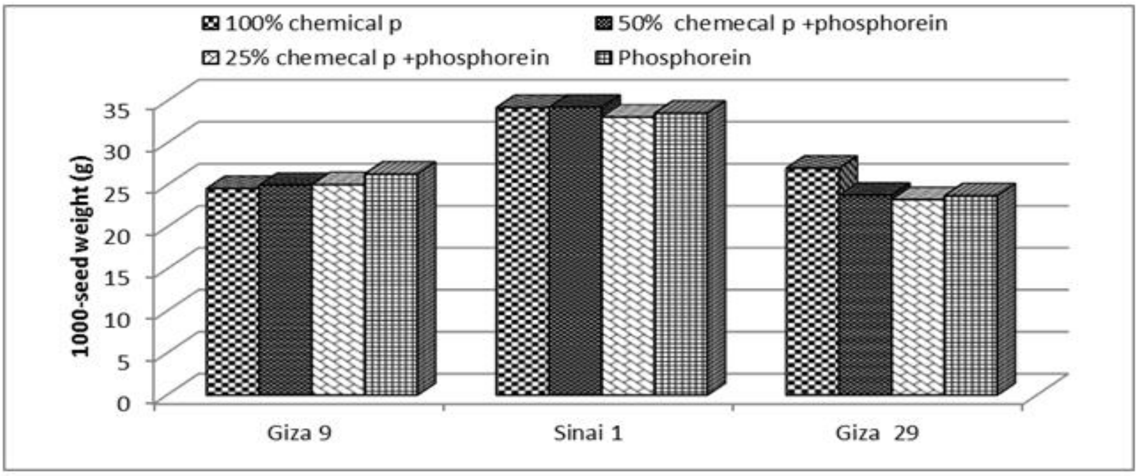

Fig. 4. 1000 weight seed (g) as affected by the interaction between lentil varieties and phosphorus fertilization regimes

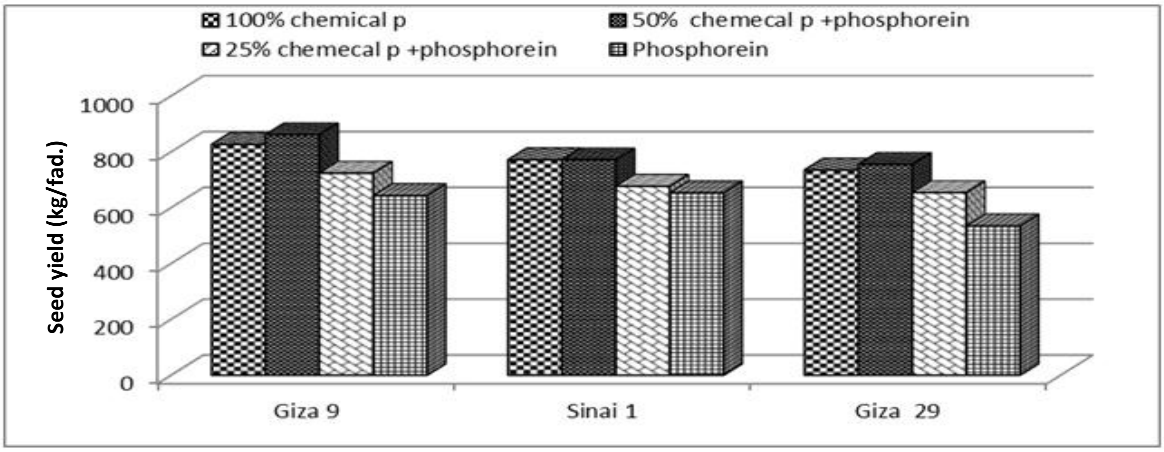

Fig. 5. Seed yield (kg/fad.) as affected by the interaction between lentil varieties and phosphorus fertilization regimes

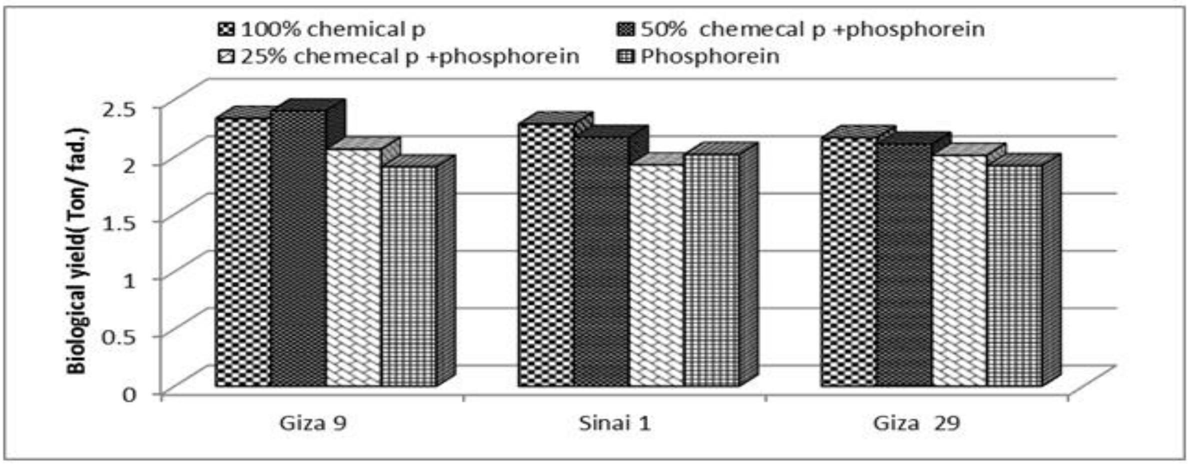

Fig. 6. Biological yield (ton/fad.) as affected by the interaction between lentil varieties and phosphorus fertilization regimes

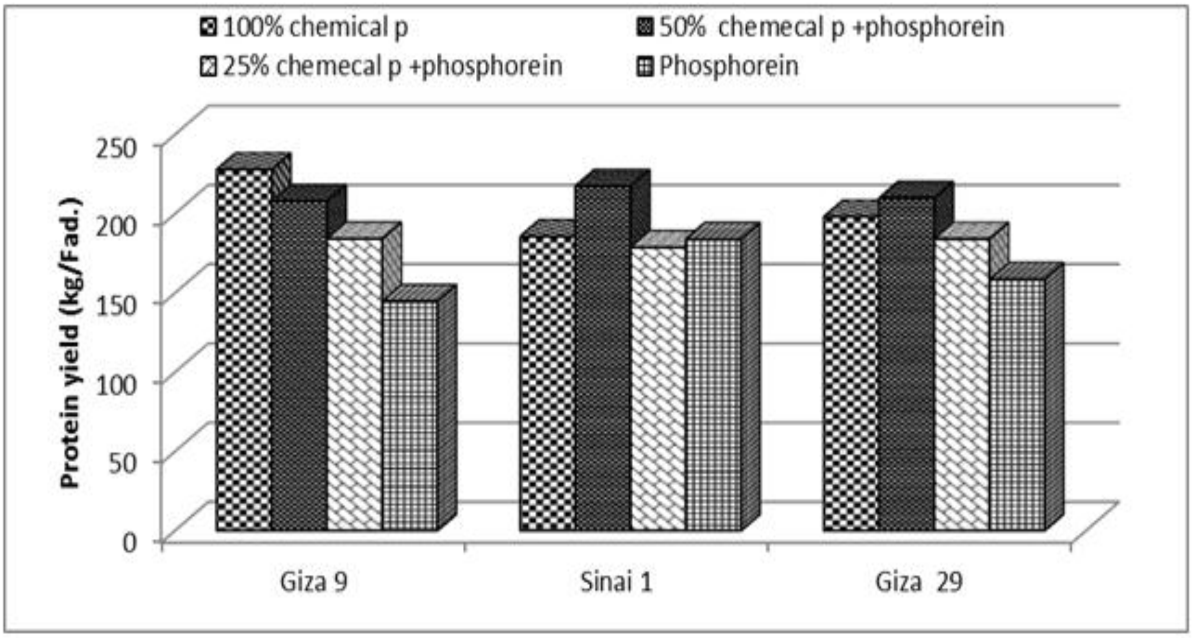

Fig. 7. Protein yield (kg/fad.) as affected by the interaction between lentil varieties and phosphorus fertilization regimes

Table 5. Protein (%), germination (%) and seedling fresh weight (g) of three lentil varieties as influenced by biochemical phosphorus fertilization regimes during 2017/2018 and 2018/2019 seasons and their combined

Main effect	Protein (%)			Germination (%)			Seedling fresh weight (g)		
	2017/18	2018/19	Comb.	2017/18	2018/19	Comb.	2017/18	2018/19	Comb.
Lentil varieties (V)									
Giza 9	25.27	24.55	24.91	96.66	96.66	96.66	0.1792	0.2340	0.2069
Sinai 1	27.03	26.32	26.68	97.67	96.33	97.00	0.1819	0.2830	0.2327
Giza29	28.71	27.56	28.13	97.67	95.33	96.50	0.1677	0.2670	0.2174
F-test	*	*	*	NS	NS	NS	NS	NS	NS
LSD at 5%	0. 53	1.24	0.86						
Biochemical fertilization regimes: (F)									
F_1	26.63	25.76	26.19	97.33	96.44	96.88	0.1768	0.2840	0.2304
F_2	27.08	26.32	26.70	98.22	95.11	96.66	0.1873	0.2950	0.2413
F_3	27.14	26.14	26.64	96.44	97.33	96.88	0.1550	0.2530	0.2040
F_4	27.16	26.36	26.76	97.33	95.55	96.44	0.1860	0.2140	0.2003
F-test	NS	NS	NS	NS	NS	NS	NS	*	NS
LSD at 5%								0.03	
Interaction									
V×F	*	*	*	NS	NS	*	*	*	NS

F_1, F_2, F_3 and F_4 are 100% chemical phosphorus (15.5 kg P_2O5/fad.), 50% of F_1 + phosphorein, 25% of F_1 + phosphorein and sole phosphorein in respective order.

Table 6. Seedling dry weight, root length, shoot length and seedling vigor index of three lentil varieties as influenced by biochemical phosphorus fertilization regimes during 2017/2018 and 2018/2019 seasons and their combined

Main effect	Seedling dry weight (g)			Root length (cm)			Shoot length (cm)			Seedling vigor index (SVI)		
	2017/18	2018/19	Comb.	2017/18	2018/19	Comb.	2017/18	2018/19	Comb.	2017/18	2018/19	Comb.
Lentil varieties: (V)												
Giza 9	0.040	0.056	0.048	3.07	3.56	3.31	9.41	11.51	10.46	12.07	14.61	13.34
Sinai 1	0.048	0.062	0.055	3.53	3.73	3.63	9.13	10.15	9.64	12.39	13.39	12.89
Giza 29	0.047	0.059	0.053	3.84	4.39	4.12	10.01	10.44	10.22	13.52	14.13	13.83
F-test	*	NS	NS	NS	*	*	*	*	*	NS	*	NS
LSD at 5%	0.0041				0.376	0.361	0.54	0.88	0.56		7.88	
Biochemical fertilization regimes (F)												
F_1	0.037	0.064	0.051	3.65	4.21	3.93	10.27	11.41	10.84	13.5	15.07	14.3
F_2	0.048	0.062	0.055	3.68	3.95	3.82	9.65	11.81	10.73	13.12	14.99	14.0
F_3	0.037	0.059	0.048	2.97	3.63	3.30	8.84	9.95	9.40	11.41	13.28	12.3
F_4	0.057	0.053	0.055	3.60	3.79	3.69	9.28	9.62	9.45	12.54	12.83	12.6
F-test	**	NS	NS	*	*	*	NS	*	*	*	*	*
LSD at 5%	0.0038			0.541	0.381	0.287		0.44	0.63	1.419	0.199	0.969
Interactions												
V×F	*	NS	*	*	*	*	*	*	*	*	NS	*

F_1, F_2, F_3 and F_4 are 100% chemical phosphorus (15.5 kg P_2O5/fad.), 50% of F_1 + phosphorein, 25% of F_1 + phosphorein and sole phosphorein in respective order.

and 11.45% over Sinai1 and Giza9, respectively (combined results). Contrary results were recorded by **Hamdi *et al* (2017), Osama *et al.* (2018)** and **Ahmed *et al.* (2019).** In addition, the variety Giza29 produced the longest radical and shoot compared to Sinai1 and Giza 9. The variation in seedling traits of lentil varieties had been shown to be affected by the genetic variability and the function of DNA, RNA and protein synthesis. Genetic variation in shoot and root of seedling lentil were observed by **Sarker *et al*. (2005).**

Effect of phosphorus treatments

Results presented in Tables 4,5 and 6 illustrate the effect of phosphorus on seed protein (%), protein yield /fad., germination (%), seedling fresh weight, seedling length and seedling vigor index of three lentil varieties. The results appeared significant differences due to the fertilization regimes except for protein (%), germination (%) and seedling dry weight, while protein yield, root length, shoot length and seedling vigor index recorded increases with applying 100% phosphorus and 50% phosphorus + phosphorein. This superiority may be due to the great importance of phosphorus in stimulate the physiological processes, which probably resulted in increases cell division of seedling. Germinative metabolic activities influencing the development of seedling **(McDonald, 2000).** Similar results were obtained by **Bijanzadeh *et al*. (2010).**

Interaction Effect

The interaction effect between the two studied factors on each of protein (%), germination (%), seedling dry weight (g), root and shoot length (cm) and seedling vigor index was significant. Giza29 lentil variety achieved the highest value for each of seed protein (%), germination (%), root and shoot length and seedling vigor index when the seed was treated by phosphorein and applying 50% of phosphorus recommended dose. While the lowest value for each of protein (%), germination (%), seedling dry weight and root length was obtained by Giza9 lentil variety with applying 100% chemical phosphorus. As shown in Figs. 8, 9, 11, 12 and 13.

Furthermore, Sinai1 gave the highest seedling dry weight when seeds were treated by phosphorein only (Fig. 10).

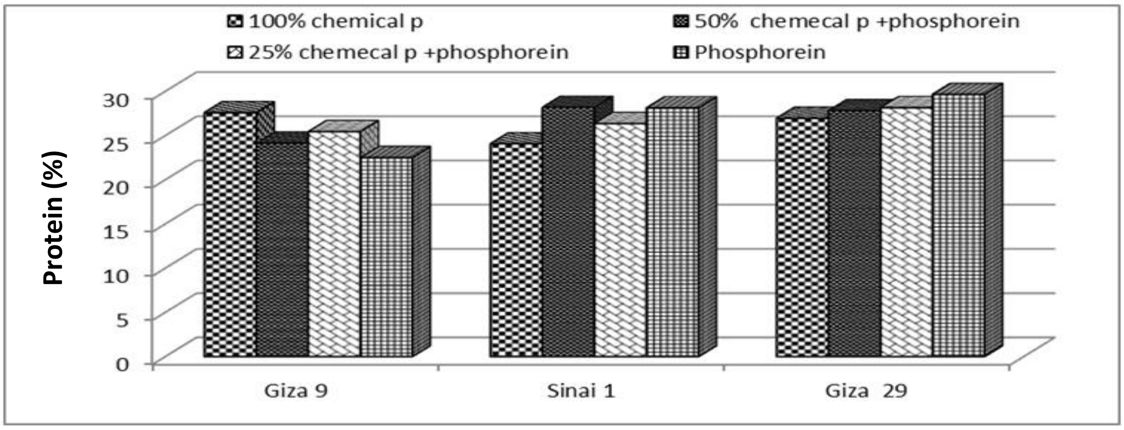

Fig. 8. Protein (%) as affected by the interaction between lentil varieties and phosphorus fertilization regimes

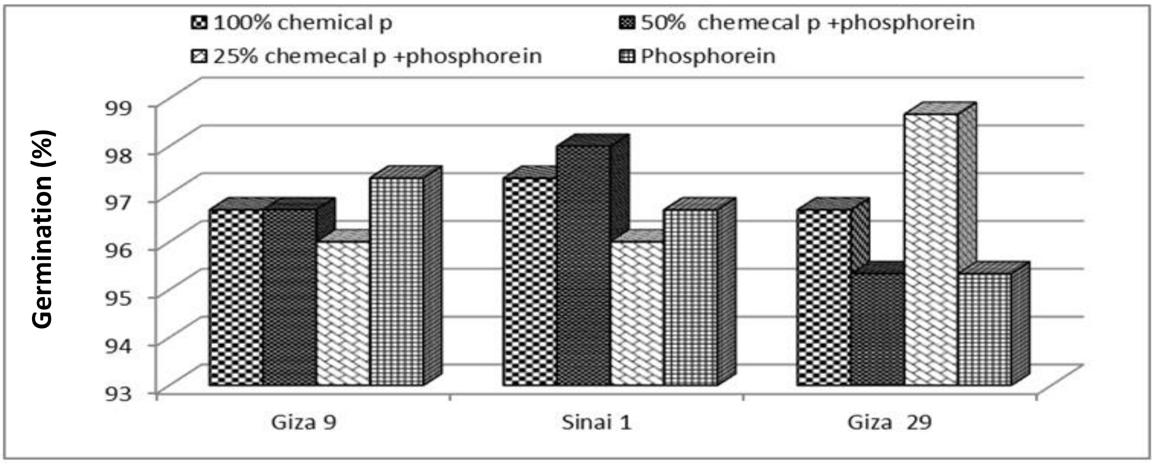

Fig. 9. Germination (%) as affected by the interaction between lentil varieties and phosphorus fertilization regimes

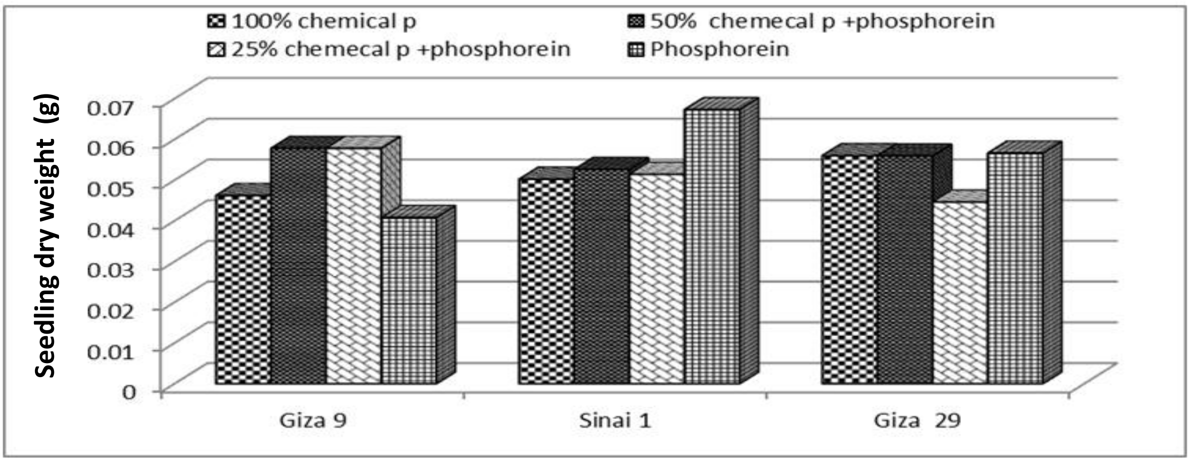

Fig. 10. Seedling dry weight (g) as affected by the interaction between lentil varieties and phosphorus fertilization regimes

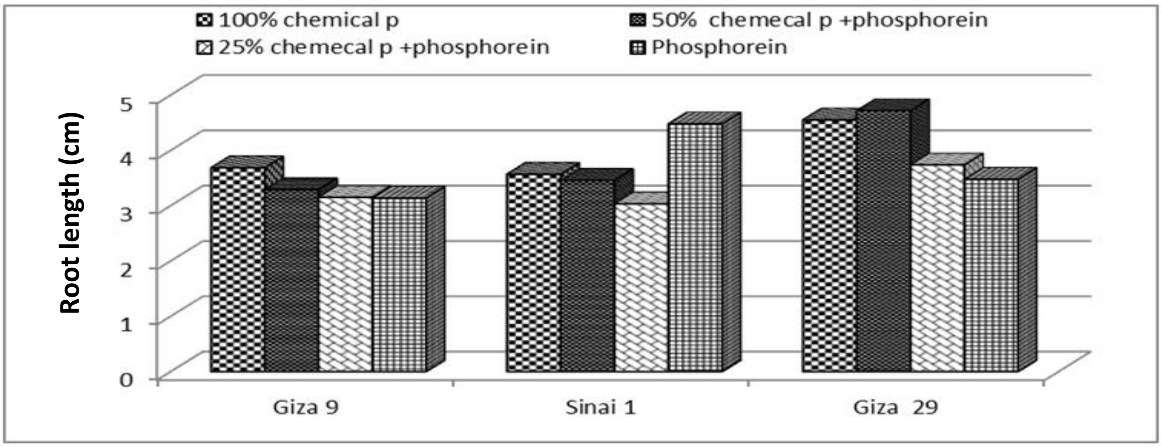

Fig. 11. Root length (cm) as affected by the interaction between lentil varieties and phosphorus fertilization regimes

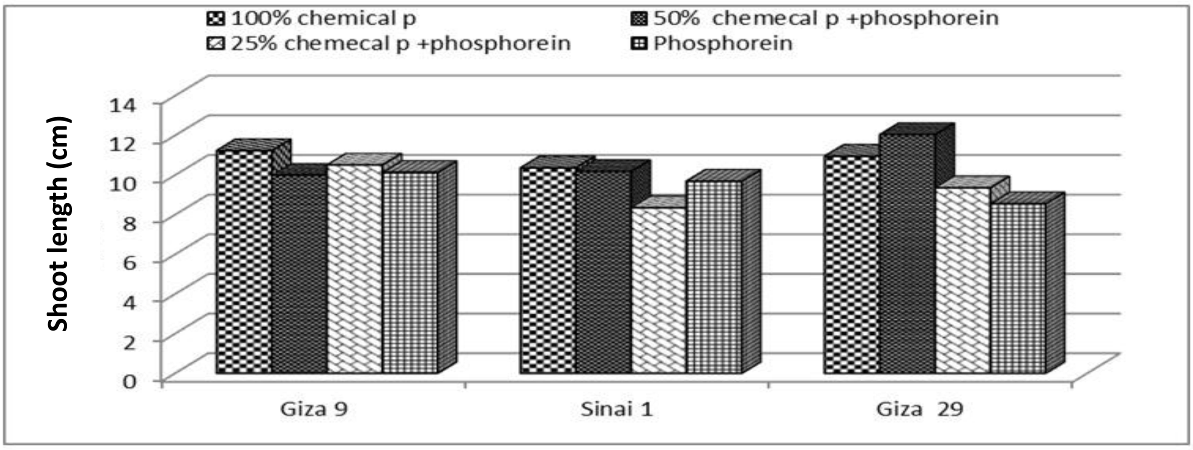

Fig. 12. Shoot length (cm) as affected by the interaction between lentil varieties and phosphorus fertilization regimes

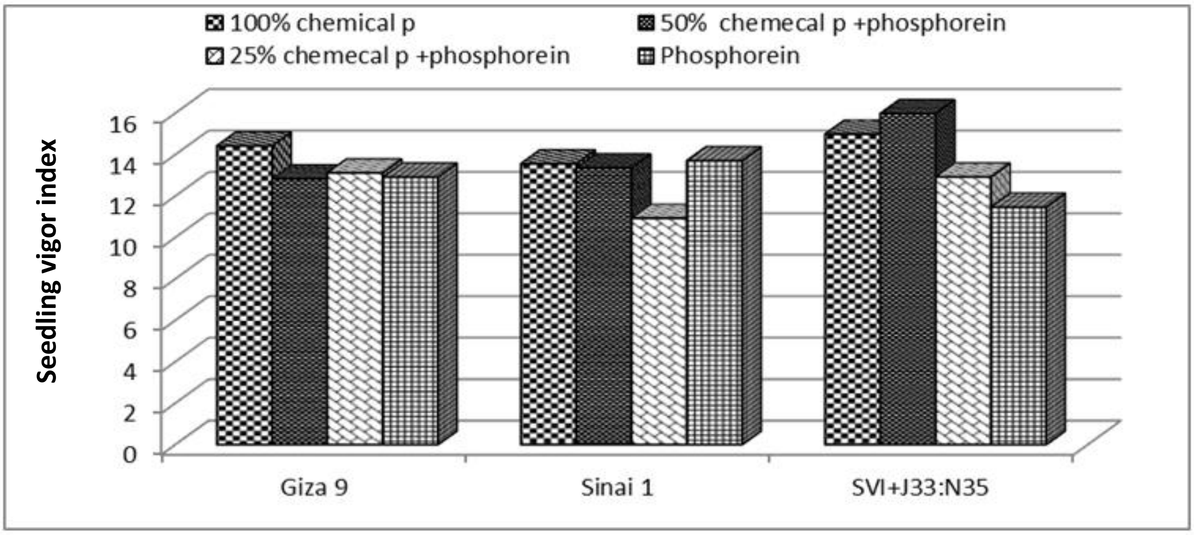

Fig. 13. Seedling vigor index as affected by the interaction between lentil varieties and phosphorus fertilization regimes

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الملخص العربي

تأثير بعض نظم التسميد الفوسفاتي الحيوي والكيماوي على محصول وصفات جودة بذور بعض أصناف العدس

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أجريت تجربتان حقليتان بالمزرعة التجريبية لكلية الزراعة – قرية غزالة جامعة الزقازيق – محافظة الشرقية ، مصرخلال موسمي الزراعة 2018/2017 و2019/2018 لدراسة تأثير أربع أنظمة من التسميد الفوسفاتي هي (100% فوسفور كيميائي بالجرعة الموصي بها (15 كجم فو$_2$أ$_5$)، 50% من كمية السماد الفوسفاتى الكيماوي الموصى بها + المخصب الحيوى فوسفورين، 25% من كمية السماد الفوسفاتي الكيماوي الموصى بها، فوسفورين وفوسفورين منفرد) على ثلاثة أصناف من العدس (جيزة 9، سينا 1 وجيزة 29). ولقد أظهرت النتائج تفوق الصنف جيزة 9 في صفات ارتفاع النبات، عدد الأفرع/نبات، عدد القرون/نبات، محصول البذور/فدان، المحصول البيولوجي/فدان وكذلك دليل الحصاد، بينما تفوق الصنف سينا 1 في وزن 1000 بذرة، في حين تفوق الصنف جيزة 29 في محتوى البذور من البروتين وطول جذير وريشة البادرات، ولقد أظهرت النتائج أن أفضل وأكبر القيم لصفات دليل البذور، محصول البذور/فدان، المحصول البيولوجي/فدان، دليل الحصاد، محتوى البذور من البروتين/طول جذير وريشة البادرات، ودليل قوة البذور تم الحصول عليها من كل من المعاملة السمادية 100% من السماد الفوسفاتي الكيماوي بالمعدل الموصى به والمعادلة السمادية 50% من السماد الفوسفاتي الكيماوي بالمعدل الموصى به + السماد الحيوي فوسفورين مع عدم وجود فروق معنوية بينهما بينما حلت المعاملة بـ 25% من السماد الفوسفاتي الكيماوي الموصى به + الفوسفورين، والمعاملة بالسماد الحيوي فوسفورين في المرتبة الثالثة والرابعة على الترتيب.

الكلمات الاسترشادية: العدس، التسميد الفوسفاتي، الأحياء، الإخصاب، الأصناف، الجودة.

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